THE EFFECTIVE DATE OF THIS ORDINANCE IS JANUARY 2, 2003

ORDINANCE NO. 02-22-318

Re: To Amend the Frederick County Roads and Streets Design Manual

RECITALS

Pursuant to the authority contained in, inter alia, the Public Local Law of Frederick County, Chapter 2-11, and the Annotated Code of Maryland, Art. 25, §1, the Board of County Commissioners of Frederick County, Maryland, in 1994, determined that it was necessary and appropriate to revise the previously enacted Roads and Street Design Manual, and by Ordinance No. 94-01-096 enacted as its replacement the present "Design Manual (Volume 1) - Streets and Roads" ("Design Manual").

Following a public hearing on April 3, 2001, the Board amended the Roads and Streets Design Manual by Ordinance No. 01-04-278.

Staff has recommended, and the Board agrees that it is appropriate at this time to again amend the Design Manual to add a section governing storm drainage conveyance.

A public hearing was held on these proposed revisions to the Design Manual on Tuesday, October 15, 2002, at which time the public was given the opportunity to comment.

NOW THEREFORE, BE IT ENACTED AND ORDAINED BY THE BOARD OF COUNTY COMMISSIONERS OF FREDERICK COUNTY, MARYLAND, that the Frederick County Roads & Streets Design Manual is hereby amended by the addition of Section 4.0 Storm Drainage Conveyance as set forth on the attached Exhibit A hereto.

AND BE IT FURTHER ENACTED AND ORDAINED, that this Ordinance shall take effect on January 2, 2003.

AND BE IT FURTHER ENACTED AND ORDAINED, that Exhibit A hereto shall not be incorporated into the Frederick County Code 1979, but shall be reproduced as part of the Roads and Street Design Manual, a separate publication, and made available to interested persons through the Division of Public Works.

THE UNDERSIGNED HEREBY CERTIFIES that the foregoing Ordinance was approved and adopted by the Board of County Commissioners of Frederick County, Maryland on the 29th day of October, 2002.

ATTEST:

_____/s/_____
Douglas D. Browning
Acting County Manager

BOARD OF COUNTY COMMISSIONERS
OF FREDERICK COUNTY, MARYLAND

By:_____/s/_____
Terre R. Rhoderick, Vice President

DESIGN MANUAL (VOLUME 1) - STREETS AND ROADS
(March 1994)

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DESIGN MANUAL (Volume 1) – STREETS AND ROADS

(March 1994)

1.0 GENERAL DESIGN GUIDELINES

1.01 Introduction:

Local residential streets are part and parcels of the neighborhoods they serve. People live on them. It is desirable, therefore, to not only move traffic safely and efficiently but to provide a residential neighborhood that is quiet, safe, pleasant, convenient, and sociable. Streets should be designed to serve the neighborhoods and we have attempted to set these standards. In addition, guidance on non-residential streets is provided.

Modifications (waivers) to the recommendations and requirements of this manual for Chapters 1 and 2 may be pursued under the authority granted by the Frederick County Subdivision Ordinance, Section 1-16-30. Modifications for Chapters 3 and 4 may be granted by the Director of Frederick County Division of Public Works or a designee.

1.02 Purpose:

The purpose of the provisions for local residential streets is to establish appropriate standards for the design of streets in residential subdivisions that will (1) promote the safety and convenience of vehicular traffic, (2) protect the safety of neighborhood residents, (3) minimize the long term costs for the maintenance and repair of streets, (4) minimize crime in residential areas , (5) protect residential qualities of neighborhoods by limiting traffic volume, traffic speed, noise, and air pollution, (6) encourage the efficient use of land, (7) minimize the cost of street construction and thereby restrain the rise of housing costs, (8) minimize the construction of impervious surface, thereby protecting the quantity and quality of the County water resources, and (9) encourage and promote pedestrian circulation. Non-residential streets have larger design parameters than local residential streets in order to account for greater traffic volumes and increased truck traffic.

1.03 Street Hierarchy

An ideal street system separates routes which carry traffic passing through
An area from streets which provide access to people within the area. All residential streets between these two extremes can be described in terms of their relative service for through-traffic movement and property access. Movement and access criteria can form the basis for an ordered classification system and appropriate design standards. A street hierarchy system is, therefore, vital in promoting safety, ensuring residential quality and maintenance efficiency, preventing crime, allowing land use efficiency, lowering housing costs, and fostering environmental protection. Frederick County requires all new streets to conform to the design standards of residential local access, sub-collector, or collector streets depending upon the manner in which the street will be used. Similarly in the hierarchy of streets a need for special purpose and non-residential streets exists. The non-residential streets are intended for the main movement of through traffic or distributed traffic (i.e. collectors and arterials) or alternatively, the delivery of traffic through and about localized retail or industrial hub.

SECTION 4
GENERAL SUBMISSION REQUIREMENTS

4.1.1 INTRODUCTION

This manual has been developed to provide guidance for the design of stormwater management and drainage conveyance systems to safely control and convey storm water runoff associated with the development of commercial and residential subdivisions and related construction projects in Frederick County, Maryland. While the requirements set forth in this manual must be complied with for public systems to be adequately reviewed by the Frederick County Division of Public Works (FCDPW), some private systems may not require review by FCDPW. However, no manual can substitute for the responsibility of the design engineer to ensure public safety and excellence of design.

4.1.2 GENERAL PLAN REQUIREMENTS

4.1.2.1 Sketch and/or Preliminary Subdivision Plans

Enough information should be shown on the sketch and/or preliminary plans to ensure that adequate space has been provided for the stormwater management facility proposed. Adequate space and lot alignment also need to be provided in addressing storm drainage conveyance systems. The information should include topography, as outlined in the Frederick County Subdivision Regulations Sec. 1-16-60 and Sec. 1-16-72, type and approximate size of the proposed stormwater management facility, approximate stormdrain alignments, location, and approximate size of outfalls into the stormwater facilities, easement locations, proposed road culvert locations, and proposed open channels.

Typically, detailed stormwater and storm drainage conveyance computations are not required at this level of detail. However, in questionable situations, such as limited space and/or steep slopes in the area designated for the proposed stormwater management facility, computations may be requested.

Careful planning of stormwater management and conveyance systems is encouraged at this stage. Additional measures that may be determined necessary during Improvement (Construction) Plan review may cause adverse impact to construction quantities and lot location and layout.

4.1.2.2 Site Plans

As with sketch and/or preliminary plans, enough information should be provided on a site plan to depict an accurate layout and size determination for both the stormwater management facility and the storm conveyance systems. The type of stormwater management facility proposed should be identified and enough area provided to allow the facility to be constructed to meet the storage requirements. Approximate pipe sizes should be shown on the site plan. As an option, the engineer may include full Improvement Plans as part of the Site Plan submission, supplying all information required for Improvement Plan approval.

4.1.2.3 Improvement Plans

An improvement plan submission must include full engineering computations, drawings, details, notes, specifications, easements, and any additional information necessary for the complete construction and inspection of the proposed stormwater management and storm conveyance systems. The computations and minimum design criteria shall be in accordance with this manual. All documents must be signed and sealed by an appropriate licensed professional in the State of Maryland.

4.2 STORM CONVEYANCE SYSTEM

4.2.1 Hydrology and Hydraulic Computations

The computation package submitted to FCDPW shall include all information to support the proposed conveyance system: specifically, a drainage area map, hydrologic computations, hydraulic calculations, hydraulic gradient information, and certified structural shop drawings for nonstandard structures. All hydrologic and hydraulic computations and improvement plans shall be developed under the direct supervision of, and sealed by, a Registered Professional licensed in the State of Maryland in accordance with COMAR 09.13.06.

The storm conveyance system shall be designed based on ultimate land use planned per the current comprehensive plan, for all contributing drainage areas. In cases where stormwater management is to be regionalized, ultimate zoning, land use shall be considered for those drainage areas to be served by the regional stormwater management facility. The Frederick County Division of Planning and Zoning should be contacted to obtain both the current and ultimate land use information for the contributing drainage areas.

4.2.1.1 Drainage Area Map

The drainage area map should be based on the most recent and accurate topographic information available for the contributing watershed. Onsite drainage divides should be based on proposed site grading plans. Offsite areas may use U.S.G.S. 7.5 minute quadrangle sheets if more accurate information is not available, however, the engineer is expected to field verify all drainage areas. The following information shall be required on the drainage area map and included in the computation package:

4.2.1.1.1 The entire drainage area served by the conveyance system shall be shown. Topography shall be included to support the drainage area delineation.

4.2.1.1.2 The outline of the proposed construction/design site, as well as all pertinent streets and rights-of-way, shall be shown to accurately depict the area under consideration.

4.2.1.1.3 The contributing area, in acres, to each inlet shall be labeled and shown with the individual drainage area delineation.

4.2.1.1.4 All storm conveyance systems shall be shown with structure numbers and pipe sizes corresponding to the computations and improvement plans. Existing systems shall be shown dashed, and proposed systems shall be shown solid.

4.2.1.1.5 All land use/zoning information shall be shown, and the runoff coefficients for the contributing area to each inlet shall be labeled.

4.2.1.1.6 Flow paths for Time of Concentration (Tc) determination shall be shown if the Tc differs from the guidelines listed in Table 2.

4.2.1.1.7 A title block shall be included with the map, including scale, revision dates and all other pertinent information.

4.2.1.2 Peak Discharge Determination

4.2.1.2.1 General Flow Equations

The rational formula shall be used to determine the peak discharge in the design of storm conveyance systems of less than 100 acres. In cases where the contributing drainage area exceeds 100 acres, the methods developed by the Soil Conservation Service, including Technical Release No. 55 (TR-55) and Technical Release No. 20 (TR-20), are recommended. Rational method shall not be used for drainage areas over 100 acres.

In the Rational Formula:

$$Q=C*I*A$$

Where;

- Q = Peak discharge of storm runoff in cubic feet per second (cfs).
- C = Runoff coefficient (See Table 1).
- I = Intensity of rainfall in inches per hour (iph). "I" is dependent on the Tc & the storm frequency (See Table 2).
- A = Contributing area in acres (ac).

4.2.1.2.1.1 Runoff Coefficient, "C"

The runoff coefficient shall be a composite of all the ultimate land uses in the contributing drainage area. The value should represent the proportion of area covered by impervious surfaces or by lawn. The following values should generally be used for "C":

TABLE 1

RATIONAL METHOD RUNOFF COEFFICIENTS

ZONE	TYPICAL LOT SIZE	TYPE OF DEVELOPMENT	"C" VALUE
VC, GC, HS		Commercial	0.90
LI, GI, MM, ORI		Industrial	0.85
R-12, R-16	Less than 6,000 sf	Residential	0.75
R-5, R-8	6,000 to 8,000 sf	Residential	0.55
R-1, R-3	12,000 to 43,560 sf	Residential	0.45
*A	2 acres	Agriculture	0.35
C	5 acres	Conservation	0.30

* For residential *Ag Cluster* developments within the *Agriculture Zone*

"C" values for zoning and land uses not listed in Table 1 above shall be determined based on SHA specifications. For inlet design, a breakdown to each inlet, shown on a detailed drainage area map, shall be provided using the following coefficients:

Impervious Area	0.90
Lawn	0.30

4.2.1.2.1.2 Rainfall Intensity, "I"

The storm rainfall intensity "I" can be determined based on the time of concentration (Tc) of flow to the storm system inlet. The time of concentration shall be determined by considering the length of time water would travel along the hydraulically most distant flow path within the contributing drainage area. Soil Conservation Service TR-55 methodology should be used for determining Tc. A minimum of five (5) minutes shall be used.

As a guide, the following time of concentrations may be employed based on the type of proposed development:

TABLE 2

TYPICAL TIME OF CONCENTRATIONS

LAND USE	"Tc" VALUE
Commercial, Industrial, Townhouse ("C" values greater than 0.60)	5 min.
Single Family Residential (1/5 to 1 ac.) ("C" values between 0.40 and 0.60)	7 min.
Single Family Residential (2 ac. or greater) ("C" values less than 0.40)	10 min.
Parks and Open Space	15 min.

Using the computed time of concentration and the appropriate storm frequency, the rainfall intensity "I" can be determined from the Rainfall, Intensity - Frequency - Duration data in Table 4.

4.2.1.2.2 Selected Storm Frequencies

The storm frequency used for the design of the conveyance system depends upon the type of system. The following is a guide to determine the appropriate storm event:

TYPE OF SYSTEM	DESIGN STORM
Storm Drain Inlets	2 year
Enclosed Storm Drain Systems	10 year
Driveway Culverts	10 year
Residential Roadside Swale	10 year – W/6" Freeboard
Natural Channels	25 year
County Road Culverts	25 year

TABLE 4
RAINFALL, INTENSITY - FREQUENCY - DURATION
(Inches per hour)

Tc (Min)	2 Year	STORM 10 Year	RETURN 25 Year	PERIOD 50 Year	100 Year
5.00	5.33	6.93	7.92	8.61	9.40
6.00	5.07	6.70	7.62	8.41	9.21
7.00	4.75	6.47	7.47	8.22	8.91
8.00	4.70	6.25	7.23	7.97	8.71
9.00	4.46	6.11	6.93	7.72	8.51
10.00	4.29	5.80	6.70	7.52	8.22
11.00	4.07	5.53	6.39	7.18	7.86
12.00	3.96	5.37	6.22	6.99	7.66
13.00	3.83	5.21	6.03	6.80	7.47
14.00	3.72	5.05	5.86	6.62	7.28
15.00	3.59	4.90	5.68	6.42	7.08
16.00	3.49	4.77	5.56	6.26	6.91
17.00	3.40	4.65	5.42	6.10	6.72
18.00	3.30	4.52	5.30	5.94	6.55
19.00	3.20	4.39	5.16	5.78	6.36
20.00	3.10	4.27	5.03	5.62	6.19
21.00	3.02	4.17	4.92	5.50	6.06
22.00	2.93	4.07	4.80	5.39	5.95
23.00	2.85	3.98	4.69	5.28	5.82
24.00	2.76	3.88	4.58	5.17	5.70
25.00	2.68	3.78	4.46	5.05	5.58
26.00	2.63	3.72	4.38	4.97	5.48
27.00	2.58	3.67	4.31	4.89	5.38
28.00	2.52	3.61	4.23	4.80	5.28
29.00	2.47	3.55	4.15	4.72	5.18
30.00	2.42	3.49	4.07	4.64	5.08
31.00	2.40	3.43	4.02	4.57	5.01
32.00	2.36	3.38	3.95	4.49	4.93
33.00	2.33	3.32	3.89	4.42	4.86
34.00	2.30	3.26	3.82	4.36	4.78
35.00	2.27	3.20	3.76	4.29	4.70
36.00	2.23	3.14	3.70	4.21	4.63
37.00	2.20	3.08	3.64	4.14	4.55
38.00	2.17	3.03	3.57	4.07	4.48
39.00	2.13	2.97	3.51	4.00	4.40
40.00	2.10	2.91	3.44	3.93	4.33

(From S.H.A. - 61.1-403.01, adjusted for Frederick County)

4.2.1.2.3 Computer Software

The design engineer may utilize computer programs for the determination of hydrology and hydraulics associated with the design of storm conveyance systems. FCDPW shall review and approve all software packages prior to the acceptance of the specific software for use in design. Currently acceptable software packages include Soil Conservation Service TR-55 and TR-20 methodologies and the Federal Highway Administration HY-8, HEC-1, HEC-2, and HEC-12 methodologies, and some HAESTED software.

4.2.1.3 Enclosed Storm Drain Systems

4.2.1.3.1 Enclosed Conveyance System Sizing

The Manning Formula shall be used to determine the appropriate pipe sizes required to convey the calculated peak discharge. The Manning Formula is:

$$Q = \frac{1.486 * A * R^{2/3} * s^{1/2}}{n}$$

with

$$R = \frac{A}{P}$$

where;

Q = Peak discharge (cubic feet per second)
A = Cross-sectional area of flow (square feet)
n = Manning's roughness coefficient
R = Hydraulic radius (feet)
s = Slope (feet per foot)
P = Wetted perimeter (feet)

The Manning's roughness coefficient "n" used for design shall be as shown in Table 5. The minimum hydraulic pipe slopes shall appear in the computations and be included on the plans.

Water shall not cross the centerline of a local street or exceed the width of eight feet during a two (2) year rainfall event. The flow across any intersection shall not exceed 2.5 cfs for the ten (10) year storm. Spread shall be calculated using FHWA Hydraulic Engineering Circular No. 12, "Drainage of Highway Pavements," from which the following equations are taken:

$$Q = \frac{0.56}{n} * Sx^{5/3} * S^{1/2} * T^{8/3}$$

and

$$d = T*Sx$$

where;

Q = Flow rate in the gutter (cfs)

Sx = Cross slope of the roadway (ft/ft)

S = Longitudinal slope (ft/ft)

T = Width of flow (spread in ft)

d = Depth of flow in the gutter at the flow line (ft)

n = Manning's roughness coefficient

4.2.1.3.2 Public Street Capacity

(Future)

TABLE 5

MANNING'S ROUGHNESS COEFFICIENT "n" FOR PIPE

PIPE MATERIAL	VALUE OF "n"
Reinforced Concrete Pipe (RCP)	0.013
Cast or Ductile Iron Pipe (CIP or DIP)	0.013
Smooth Bore, High Density Polyethylene Pipe (HDPEP)	0.011
Corrugated Polyethylene Pipe (CPEP)	0.020
Aluminized Type 2 Corrugated Steel Spiral Rib Pipe (3/4"x3/4"x7-1/2" corrugations) (ALCMP-SR)	0.013
Aluminized Type 2 Corrugated Steel Pipe (2-2/3"x1/2" corrugations) (ALCMP)	
12" to 36" Diameter	0.019*
42" to 96" Diameter	0.014*
Aluminized Type 2 Corrugated Steel Pipe (3"x1" helical corrugations) (ALCMP)	
36" to 84" Diameter	0.021*
96" to 144" Diameter	0.024*
Aluminized Type 2 Corrugated Steel Pipe (2-2/3"x1/2" annular corrugations) (ALCMP)	0.024
Aluminized Type 2 Corrugated Steel Pipe (3"x1" corrugations) (ALCMP)	0.028
Aluminized Type 2 Corrugated Steel Pipe Arch (ALCMPA)	0.024
Structural Plate Pipe (6"x2" corrugations)	0.034
Aluminized Type 2 Corrugated Steel Pipe Concrete Lined (ALCMP-CL)	0.013
Monolithic Concrete Box Culvert	0.015

*Limitations: While it is true that helical corrugated metal pipe may have a lower "n" value than annular corrugated metal pipe, care should be exercised in the use of the reduced values. Since the low values depend upon the development of spiral flow across the entire cross-section of pipe, the designer must assure himself that fully developed spiral flow can occur in his design situation. It is recommended that the "n" values for annular pipe be used under the following conditions:

1. Partly full flow in the pipe
2. Extremely high sediment load
3. Short culverts less than 20 diameters (Min. length equals 20 x pipe diameter)
4. Non-circular pipes
5. Partially paved pipes

(From S.H.A. - 61.1 - 404.1)

4.2.1.3.3 Inlet Sizing and Capacity

4.2.1.3.3.1 Curb Opening Inlets on Grade

Curb opening inlets shall be sized to capture at least 85% of the flow coming to them during a two (2) year storm and shall be located in accordance with Sec. 4.2.2.2.4 through Sec. 4.2.2.2.8. These inlets shall be located at the uphill side of all public or private intersections where the flow exceeds 2.5 cfs. Curb opening inlets without grates shall be sized based on the following equations from FHWA Hydraulic Engineering Circular No. 12, "Drainage of Highway Pavements":

The length of curb opening required for total interception of gutter flow is:

$$Lt = 0.6 * Q^{0.42} * S^{0.3} * \left(\frac{1}{n * Sx}\right)^{0.6}$$

where:

Lt = Curb opening required for 100% flow interception (ft)

Q = Gutter flow (cfs)

S = Slope of gutter (Street Slope) (ft/ft)

Sx = Pavement cross slope (ft/ft)

n = Manning's roughness coefficient

The efficiency of curb opening inlets shorter than the length required for total interception is determined by the following equation:

$$E = 1 - \left(1 - \frac{L}{Lt}\right)^{1.8}$$

where:

E = Interception efficiency of an inlet (in decimal form)

L = Actual curb opening

Lt = Curb opening for total interception

4.2.1.3.3.2 Curb Opening Inlets on Sumps

The length of a curb opening inlet in a low point (sump) shall be sized based on the following equation:

$Q = 3.1(Ph^{3/2})$

where:

- Q = Capacity (in cubic feet per second)
- P = Perimeter of grate opening (ignoring bars and with no curb opening - in feet) times 0.75 (75% to account for inlet clogging).
- h = Head over grate (in feet) (Note: strictly applicable only where h is less than 0.4 feet.)

Maryland State Highway Administration design information shall be used for other inlet types. Equations, nomographs and other support information for other inlet types shall be included in the design computation package for review and approval by FCDPW.

4.2.1.3.3.3 Swale and Yard Inlets

In residential subdivisions swale inlets shall be utilized within roadside ditches where the flow depth of the ditch is greater than one foot (1') based on a ten (10) year storm frequency, or where the maximum average flow velocity in a stabilized grass swale exceeds four feet(4')per second. Swale inlets shall be sized in accordance with Maryland State Highway Administration criteria and computations included in the design package. Top elevations, as shown on the Structure Schedule, shall be at the grate elevation.

Yard inlets shall be placed where the ten (10) year storm runoff across a property line exceeds four (4) cfs, or where insufficient grade exists for the conveyance of surface flow to a street or roadside ditch. A sump condition shall be created at all yard drains to assure 100% capture of a ten (10) year storm. Adequate means of overflow shall be provided for larger storm events so as not to adversely impact private property. The water surface elevation of the ten (10) year storm shall be shown on the profile.

4.2.1.3.4 Manhole, Inlet, and Field Connection Energy Losses

Head loss computations shall be computed for all storm drain structures using the following equations:

$$HL = \frac{Vop^2 - Vr^2}{2 * g}$$

For manholes and inlets;

$$Vr = \frac{\left(Q * V * \cos\frac{\theta}{2}\right) ip1 + \left(Q * V * \cos\frac{\theta}{2}\right) ip2 + \ldots}{Qop}$$

For field connections;

$$Vr = \frac{Qip * Vip}{Qop}$$

where:

HL = Head loss (ft)

V = Pipe velocity (fps)

Vr = Resultant velocity (fps)

Q = Flow rate (cfs)

ip = Inlet pipe

op = Outlet pipe

θ = Angle between inlet and outlet pipes

g = Acceleration of gravity (32.2 ft/sec/sec)

The invert difference between inlet and outlet pipes may be determined by the head loss (HL) without adjustment. A minimum invert difference of 0.1 feet shall be considered for all manholes and inlets.

4.2.1.3.5 Hydraulic Grade Lines

The hydraulic gradient for the ten (10) year design storm shall be shown on all profiles for pipes 24 inches or larger. The gradient shall take into consideration pipe friction losses, tailwater at pipe outfalls, losses in the structures and other applicable conditions. If no tailwater condition exists, begin the analysis at the crown of the pipe.

All enclosed systems shall be designed so that they will generally operate without hydrostatic pressure under the design flow conditions. Where the hydraulic gradient is greater than one foot (1') above the crown of the pipe, special joint treatment shall be required per ASTM standard as follows:

Pipe Material	**Specification**
HD PEP	ASTM D3212
RCP	ASTM C361 or ASTM C443/AASHTO M198
Metal Pipe	O-Ring Rubber Gasket or Sleeve Gasket

Storm drains designed in locations where one or more of the following conditions exist, may be required to provide special joint treatment as described above:

1) Karst topography
2) Under public paved areas
3) Within 5' horizontally of other utilities
4) Other extenuating circumstances under which exfiltration could create a safety/health hazard.

The hydraulic grade line shall start at the storm system outlet and shall account for any outfall tailwater conditions. The existing or proposed design storm tailwater surface elevation shall be computed and shown on the profiles.

4.2.1.4 Open Channels

Peak discharge computations for all open channels shall be provided based on Manning's Equation (See Section 4.2.1.3.1). The roughness coefficients used for design of open channels shall be as shown in Table 6. Each channel design shall be accompanied with a typical section, a plan view and slope information, with the typical section location clearly marked for each reach on the plan. In the case of existing channels, field run topography may be required to verify channel adequacy.

TABLE 6

MANNING'S ROUGHNESS COEFFICIENTS FOR OPEN CHANNELS (From S.H.A. - 61.1 - 404.1)

GUTTERS, DITCHES, AND CHANNELS	VALUE OF "n"
Concrete or Bituminous Lined Channels	0.013
Grass Swales - Flow Greater than 6"	0.040
Grass Swales – Flow Less than 6"	0.060
Gabions	0.030
Rip-Rap	0.035
Channels not maintained, uncut weeds & brush	0.08 to 0.12
Natural Stream Channels	0.035 to 0.150
Permanent Turf Reinforcement (Enkamat, Miramat, Tri-lock, Pyramat, Etc.)	Per Manufacturer's Specifications

4.2.1.4.1 Designed Channels (To be constructed)

Open channels may be designed to convey stormwater on residential lots of ½ acre or less where the volume of flow for the ten (10) year storm event is less than four (4) cubic feet per second or where the number of lots being crossed by drainage is four (4) or fewer. These channels shall be designed at a minimum slope of two (2) percent, trapezoidal in shape or parabolic with side slopes of 3:1 or flatter. No V ditches will be allowed.

Open channels for lots larger than ½ acre or in open space areas may be designed to convey drainage across more than four (4) lots. Where possible, these channels shall be designed at a maximum slope of ten (10) percent, with minimum velocities of two feet (2') per second for the two (2) year storm. The maximum velocity shall also be based on the ten (10) year storm and the lining used to avoid erosion problems (See Appendix 22). In cases where the minimum slope can not be achieved or where springs are encountered, a pilot channel may be required. This channel may consist of a French drain, concrete flume, perforated PVC pipes, or other *materials acceptable to FCDPW.

The open channel system shall be vegetated and may be parabolic or trapezoidal in shape. The maximum velocities through the channel shall not exceed erosive velocities for the type of stabilization used.

- Rip –rap shall not be used in residential areas.

4.2.1.4.2 Natural Non-Engineered Channels (Existing)

Any natural stream channel receiving additional offsite water from upstream development must be analyzed to assure safe conveyance of the ultimate ten (10) year flow. The existing stream must remain stable under ultimate design conditions. Computations shall be provided by the engineer comparing the pre-developed flow conditions of the stream during the ten (10) year storm event with the ultimate flow conditions as a result of the proposed development. Computations modeling the proposed stabilization practices shall be provided to ensure adequacy.

Stream stabilization measures may include, but are not limited to, any or a combination of the following practices:

4.2.1.4.2.1 STREAM BANK PROTECTION that may include riprap, root wads, brush bundles or other means of protecting isolated areas from potential stream bank erosion.

4.2.1.4.2.2 DROP STRUCTURES that may be constructed using gabions, or logs to create defined areas for velocity dissipation.

4.2.1.4.2.3 PARALLEL PIPE SYSTEMS which consist of a means of splitting part of the increased runoff and conveying that flow through an enclosed pipe system parallel to the existing stream and discharging the water in an area capable of handling the increased flow.

4.2.1.4.3 Roadside Swales

All open section roadways, whether designed as part of a new subdivision or upgraded as part of a road widening, shall have drainage swales provided for storm water conveyance. Roadside swales shall be capable of conveying the ten (10) year storm. Computations may be required to verify capacity and velocity. The minimum slope for a vegetated swale shall be one) percent (1%). Low flow channels, such as French drains, concrete lined, PVC drain pipes, etc. may be used for slopes less than one percent (1%).

The design must include information pertaining to the water velocity, flow depth, and typical section of the swale. The flow velocities shall not exceed those allowed by the soils and vegetated cover proposed for the swale. The swale must flow into an adequate outfall capable of handling the storm runoff in a non-erosive fashion.

4.2.1.5 Culverts

4.2.1.5.1 County Road Crossings

All culverts designed to convey streams and storm drainage under road crossings shall be sized to carry the 25 year ultimate storm based on ultimate zoning with one foot (1') of freeboard vertically from the edge of paved travelway.

Computations shall also be provided to evaluate the impact of the 100-year storm on the road crossing. Flow over the road surface shall be kept below twelve inches during the 100 year storm. Note that the following requirements need to be met:

1. The maximum headwater must be less than 1.5 times the depth of the culvert. This means that the culvert should not cause water to pond for a depth higher than one and one-half of the depth of a culvert (e.g., for a 48" RCP, the maximum headwater is
   1.5 x 48" = 72" = 6'). Stormwater management facilities are exempt from this rule.
2. The maximum headwater should be less than five feet (5') above the crown (top) of the culvert, except where the road is being used to store runoff.

Road crossings shall be sized based on headwater and tailwater conditions using culvert design procedures, such as Federal Highway Administration Report No. FHWA-IP-85-15, Hydraulic Design of Highway Culverts (HDS No. 5), FHWA Culvert Analysis, HY-8, Maryland State Highway Administration (MSHA) Design Manual, or others acceptable to Frederick County Division of Public Works. Outlet protection shall be designed to reduce velocities to non-erosive conditions.

4.2.1.5.2 Driveway Culverts

All driveway culverts shall be designed to fully convey the ten (10) year storm. In most cases, the minimum culvert size shall be 15 inches or a pipe of an equivalent flow area. Smaller pipe sizes may be allowed with proper justification and approval from the Division of Public Works. Computations may be required to justify the size of the farthest (largest) downstream culvert size shown.

4.2.1.6 Energy Dissipaters

Acceptable energy dissipation measures shall be placed at all storm drain outlets. They shall be designed to reduce pipe outlet velocities to a velocity that the downstream conveyance system can handle without causing erosion problems during a ten (10) year storm. Outfalls should not terminate at the top or on the sides of slopes where erosive velocities could be regenerated beyond the limits of the dissipater. Rip Rap shall not be used unless all other energy dissipation devices are found to be impractical.

A typical section and plan view of the energy dissipater shall be provided with the construction drawing details. Additionally, the dissipater shall be shown graphically on the storm drain plan view with existing and proposed grading continuing to the receiving channel, but not less than 100 feet. Energy dissipater information shall include, at a minimum, material type, thickness, side slopes, depth, length, and type of blanket. The design of a riprap outlet shall be based on Soil Conservation Service Methodology or other acceptable methods approved by FCDPW.

4.2.1.6.1 Filter Fabric

A filter fabric shall be placed between the riprap blanket and the underlying soil surface. The filter fabric shall be approved by Frederick County Division of Public Works. The filter fabric proposed is to be Geotextile Class 'C' meeting ASTM D 1682 for grab tensile strength
(200 lbs. min.) and ASTM D 3786 for burst strength of 320 pounds per square inch minimum. Examples are to be shown on the plan.

4.2.1.6.2 Riprap Outlet Shape

The riprap channel bottom width shall be equal to the width of the flared end section, if used, or 1.75 times the inside diameter of the outlet pipe or outlet width. The riprap channel side slopes shall be a maximum of 2:1. The riprap outfall shall meet the requirements of either the Soil Conservation Service or the Maryland State Highway Administration. Blanket thickness shall be 2.0 times the d_{50} stone size or the theoretical diameter of the maximum stone within the call of riprap required, whichever is greater.

4.2.1.7 Safe Conveyance Analysis

Properties discharging less than four (4) cubic feet per second in a ten (10) year storm and properties which contribute less than 10% of the total flows in a 10 yr storm up to the study point will not be required to perform a safe conveyance analysis.

Developers may choose to manage the 2, 10 and 25 yr storms to pre-development flow rates in accordance with the stormwater management ordinance and design guidelines, in lieu of addressing safe conveyance requirements.

In order to protect downstream conditions, the County will require
an analysis of the effect of runoff from developed properties on existing road culverts, stormdrain conveyance systems, roadside ditches, stream channels, or other conveyance systems. Safe conveyance means the adequate capacity of downstream systems to carry concentrated flows, (storm events in accordance with this manual) or in a non-erosive manner.

When analyzing the adequacy of the downstream conveyance system, the rational method shall be used to determine the flows to the study point. Drainage areas and times of concentration should be determined based on, in order of preference; field run topography (if available), aerial photography, and USGS quad maps. C valves should be determined based on the current comprehensive plan.

If a downstream system is found to be inadequate in current conditions, and the proposed development does not increase flows (for the design storms specified in this manual) by greater than 10%, that applicant will not be required to improve the existing system.

This analysis of the impacts of stormwater flows downstream in the watershed shall be performed to a point downstream of the first downstream tributary whose drainage area equals or exceeds the sites contributing area.

In cases where inadequate downstream conditions exist, the Division of Public Works will consider a shared solution based on a prorata share.

Any staff determinations regarding the scope or requirement of Safe Conveyance Analysis or the scope of required off-site improvements resulting from the analysis are to be appealed to the Director of the Division of Public Works.

4.2.2 IMPROVEMENT PLAN DESIGN GUIDELINES

The improvement plans that are to be used for construction shall be submitted to Frederick County Division of Public Works (FCDPW) in conformance with the requirements of "THE SITE PLAN AND SUBDIVISION IMPROVEMENT PLAN MINIMUM SUBMISSIONS GUIDELINES" and shall include sufficient information for the accurate installation of all storm conveyance systems. The plans shall be complete, reflect sound engineering practices, and be signed and sealed by a Maryland Registered Professional before paper review copies are submitted to FCDPW for review. Once all comments have been addressed to the satisfaction of all review agencies, mylars can be submitted to the Soil Conservation Service for signature. After Soil Conservation Service signature, the mylars and mylar sepias may be submitted to FCDPW for signature.

4.2.2.1 Pipes

Pipe size shall be determined as previously discussed in this manual. The pipe to be used shall be determined by the type of application, the characteristics of the runoff and the properties of the soils that will surround the pipe within the trench.

4.2.2.1.1 Pipe Materials

The various pipe materials shall meet the criteria set forth in SECTION 905-PIPE of the Maryland Department of Transportation, State Highway Administration, Standard Specifications for Construction and Materials,
Oct., 1993 edition (MSHA Specs), or as amended. For public rights-of-way, TABLE 7 addresses the allowable storm drain pipe materials to be used.
Pipe type, class, or gage shall be specified on the profiles and in the pipe schedule. The depth of cover and bedding material shall be based on manufacturer's specifications. Pipe schedules will only be required for public systems.

TABLE 7

***ALLOWABLE STORM DRAIN PIPE FOR FREDERICK COUNTY**

MATERIAL	DESIGNATION
Reinforced Concrete Pipe	RCP
Aluminized Type 2 Corrugated Steel Pipe	ALCMP
Smooth Bore, High Density Polyethylene Pipe, Type "S"	HDPEP
Cast or Ductile Iron Pipe	CIP or DIP
Polyvinyl Chloride Pipe, Sch. 40 or Sch. 80	PVC

*Others as approved by Frederick County Division of Public Works

4.2.2.1.2 Minimum Pipe Size

The minimum pipe size for any storm drain pipe considered to be a component part of the public storm drainage system shall be 15 inches in diameter.

4.2.2.1.3 Cover and Loading Requirements

One foot minimum cover shall be provided over the outside of the pipe. Additional cover may be required as directed by the pipe manufacturer or the engineer, depending upon the application. In road crossing applications and under paving, the one foot (1') minimum criteria shall be measured from the bottom of the bituminous base course.

4.2.2.1.4 Curved Pipe Systems

Pipe systems with the capability of joint deflection may be used for pipes greater than 24" in diameter. Pipe deflection shall follow the manufacturer's specifications. All pertinent data is to be shown on the plan: i.e., radius, chord, tangent length, curve length, PC, PT, and Delta.

4.2.2.1.5 Pipe Slope

To enhance self-cleaning characteristics, pipes shall be designed on an actual slope of at least one percent (1%). Storm drain may need to be installed on slopes of less than one percent (1%), under extreme circumstances. In these cases, the pipe shall have a smooth interior and velocities greater than two (2) feet per second for the two (2) year storm, with proper justification of need provided. Where slopes of any pipe exceed 20%, concrete anchors will be required per Frederick County Standard Detail No. 106 (See Appendix 23).

4.2.2.2 Manholes and Inlets

All storm drain structures shall be specified by MSHA standards or as previously approved by FCDPW. All nonstandard or modified structures shall be approved by FCDPW first and a detail shown on the construction plans. The type, size and MSHA Structure Number of the proposed structure is required. All inlet structures shall be sized as previously presented with support information provided in the design computation package. The structures are to be numbered and listed on the structure schedule. Structure numbers are to match the drainage area map and computations.

4.2.2.2.1 Manhole and inlet structures shall be spaced as follows:

15” - 24” pipe	400’ max
27” - 42” pipe	600’ max
48” or larger pipe	as necessitated by site conditions and maintenance equipment

4.2.2.2.2 All inlet and manhole structures shall provide positive flow through the structure. The invert drop through the structure will be based on hydraulic losses calculated in accordance with Section 4.2.1.3.4.

A minimum drop of 0.1 foot is to be provided. Where the drop through a structure is greater than that which can be accommodated by a shaped channel with the invert on a one and one-half foot horizontal to one foot (1’) vertical slope, the bottom of the structure shall be lined with granite blocks at least four inches (4”) thick. No shaped channel will be required for this type of construction, but the bottom of the structure shall slope at least one-half inch per foot towards the invert of the outlet pipe.

4.2.2.2.3 Field connections of branch lines into main line pipes may be used only where the main line pipe involved is 27 inches in diameter and larger. The diameter of the incoming branch line is not to exceed 50 percent of the main line diameter. The branch line should enter the main line at an angle between 90 degrees to 115 degrees at the main line pipe centerline.

4.2.2.2.4 Street inlets in sump areas shall be located at the low point of the street grade. One hundred percent (100%) capacity is to be provided to allow interception of flows that bypass other inlets.

4.2.2.2.5 Curb inlets shall be placed in line and on grade with the proposed curb and gutter. Curb inlets should be placed far enough from any curb fillet to maintain a standard localized depression. If three inch (3") mountable curb is used, a ten foot (10') transition to all structures will be provided. Top of curb elevations shall be provided.

4.2.2.2.6 Non-standard inlets and those in excess of 20 feet (20') require special design approval by Frederick County Division of Public Works.

4.2.2.2.7 Inlets placed within the public road right-of-way shall have traffic bearing grates per MSHA Specifications.

4.2.2.2.8 Inlet openings within the public road right-of-way or within residential subdivisions shall limit incoming ditchline opening sizes to four (4) inches max. Horizontal double-dipped galvanized smooth bars and/or angle iron are to be bolted to the structure as needed. Other acceptable methods may be used as an alternative to protect the opening.

4.2.2.3 Pipe and Culvert Entrances

4.2.2.3.1 Pipe and culvert entrances are not to be located on developed lots unless an alternate location is not feasible. The 25-year water surface elevation shall be shown on the profile. Generally, lots should be located outside of the area inundated by the 100 year storm backwater.

4.2.2.3.2 Suitable topographical information is to be provided on the plan view to show drainage path(s) to the entrance structure and to ensure interception of flow. The channel invert, top of structure elevation in sump condition and top of banks of incoming drainage course(s) shall be shown on the plan view and profile. Riprap shall be provided as necessary to alleviate erosion potential created by the transition from the channel into the pipe or culvert entrance.

4.2.2.3.3 Pipe and culvert entrances may be constructed with end sections or headwalls for pipes smaller than 24 inches in diameter. Pipes equal to or larger than 24 inches in diameter shall be constructed with a concrete headwall.

4.2.2.3.4 A cutoff wall may be used for pipe entrances when future extension of the system is anticipated within a five (5) year time frame. The structure shall be located sufficiently beyond the development so that regrading will not be required on occupied lots of this development when the system is extended.

4.2.2.4 Pipe and Culvert Outfalls

4.2.2.4.1 Outlets are not to be located on developed lots with lot areas less than 30,000 square feet except in extenuating circumstances and with permission of FCDPW. Outfalls shall be located at the bottom of slopes, near a receiving stream or other area that will adequately handle the concentrated flow. Suitable field run topographic information shall be furnished on the plan and profile views to show the drainage path from the structure to an existing established drainage course.

4.2.2.4.2 All storm drain outfalls are to terminate prior to a downstream property line and the drainage pattern reestablished as close to a natural and pre-developed state as possible. Exceptions may be made in situations such as continuous downstream development or with written agreement from downstream property owner(s) in conjunction with non-erosive conveyance of runoff.

4.2.2.4.3 Erosion protection is to be provided at all outfalls. Transition of the erosion protection section to the natural section shall be shown in the plan view and cross-section. The channel invert and tops of banks of the receiving drainage course are to be shown on the plan and profile views. (See Section 4.2.1.6)

4.2.2.5 Required Plan Information

4.2.2.5.1 Plan View

4.2.2.5.1.1 The information that must be included for each run of storm drain pipe shall include the following: All pipe sizes are to be clearly labeled. All manholes, inlets, headwalls, etc., shall be clearly numbered and shall match the drainage area map, computations and pipe profiles. All structures shall be tied to features on the plan such as centerline stations or property lines.

4.2.2.5.1.2 An adequate overflow path for the stormwater is to be shown on the plan view if the path does not follow directly over the pipe. In most cases arrows will suffice to show flow paths. Where applicable, grading will be required to ensure the safe conveyance of overflow. For these cases, grading plans showing existing and proposed contours on plan view, as well as cross-sectional details, are required.

4.2.2.5.1.3 Storm drain running parallel to property lines shall be offset from the property line by a minimum of five feet (5') to allow for fencing and planting.

4.2.2.5.2 Profile View

4.2.2.5.2.1 Profiles of all proposed storm drains and culverts shall include, at a minimum, the following information:

1. Existing and proposed utility crossings;
2. Pipe size, type, and slope;
3. Class or gage;
4. Section length measured from structure to structure;
5. Invert elevations at each structure and at outfalls;
6. Flow characteristics (Q_{10}, V_{10} and the minimum slope (S_{min}) required for full flow in pipe);
7. The existing ground and proposed grade over the proposed system;
8. V_{10} actual for the proposed pipe slope at the outfall.

4.2.2.5.2.2 The hydraulic grade line for the ten (10) year storm shall be shown on all pipe profiles and at structures per Section 4. 2.1.3.5.

4.2.2.5.2.3 A pipe schedule tabulating pipe lengths by diameter and class or gage to be used shall be included on the drawings with the pipe profiles. A structure schedule which outlines the type of structure being used, the appropriate MSHA standard for that structure, structure ties to lots or road centerlines, elevations to the top of the structure and any other pertinent information required for construction shall also be included.

4.2.2.6 Clearance with Other Utilities

4.2.2.6.1 All existing and proposed utilities crossing or parallel to designed storm drain systems shall be shown on both the plan view and profile views.

4.2.2.6.2 A minimum vertical clearance of 12 inches and a minimum horizontal clearance of five feet, wall to wall, shall be provided between storm drainage lines and other utilities. Exceptions may be granted on a case-by-case basis when justified. If other regulations are more restrictive they shall apply.

4.2.2.6.3 The crossing angle between storm drain systems and any other utilities shall not be less than 45 degrees. Exceptions may be granted on a case-by-case basis.

4.2.2.6.4 Erosion protection, such as curlex or a permanent type matting, shall be provided where concentrated storm water flows across the trench of other utilities.

4.2.2.7 Open Channels: Designed and Natural

4.2.2.7.1 Channel inverts and tops of banks shall be shown on plan views for all designed open channels and any work associated with existing channels. Limits and types of bank protection, design flow rates, actual velocities and water surface elevations shall also be detailed.

4.2.2.7.2 The limits of the 100-year floodplain shall be shown. The minimum setbacks between any building and the 100-year floodplain shall be in accordance with the Frederick County Zoning Ordinance and other applicable codes.

4.2.2.8 Storm Drain Plan Revisions

In most situations, minor stormdrain and/or stormdrain structure revisions may be submitted for review and approval on a red-lined, blue print copy of the approved plans. The revisions shall be completed on both the plan view and profile, and all pertinent information provided. Pertinent information includes, but is not limited to:

1. Slope changes for the stormdrain shown on the profile sheet(s);
2. Computations necessary to verify stormdrain capacity should the stormdrain slope or size be decreased;
3. Conflicts with other utilities, both horizontal and vertical;
4. Changes to a stormdrain structure, including top elevations, depth of structure, dimensional changes, etc;
5. Grading modifications associated with the change shown on the plan view and the profile;
6. Other information as deemed necessary on a case-by-case basis;
7. Revised mylars must then be provided for signature.

Those modifications involving more significant changes must be submitted as a formal plan revision with supporting engineering information and new Frederick County Division of Public Works signature blocks. To facilitate the review of these revisions, all changes should be clouded or distinguished from the previously approved plans by another means. Supporting information shall include that outlined above or as needed on a case-by-case basis.

4.2.2.9 Special Structures

All structures which do not meet standard Maryland State Highway Administration details and specifications, such as flow splitters or large box culverts, shall be detailed on the improvement plans or shop drawings and signed, sealed and certified by a registered professional engineer licensed in the State of Maryland. The detail(s) shall include wall thickness, reinforcement details, elevations, etc. Those culvert-type structures, either single or multiple cell, spanning 20 feet or more shall also be reviewed by the Office of Transportation Engineering.

4.2.2.10 Stormdrain Easements

All stormdrain, both public and private, used as an essential component for conveyance of stormwater to a stormwater management facility shall be shown in a stormdrain easement. Private stormdrain requiring a stormdrain easement is that stormdrain where, if failure of the system were to occur, stormwater runoff would bypass the stormwater management facility. The minimum easement width shall be 30 feet. Special consideration for smaller stormdrain easement widths shall be reviewed by FCDPW on a case-by-case basis with adequate justification. In conjunction with the easement, a deed of easement and maintenance agreement must also be executed.

4.2.2.10 Asbuilts (Future)

DESIGN MANUAL (Volume I) – STREETS AND ROADS

APPENDIX

(Quick Reference Code Where Applicable)

APPENDIX 21

FREDERICK COUNTY, MARYLAND

Standard Pipe and Structure Schedules

		STRUCTURE SCHEDULE		
STR. NO.	STRUCTURE TYPE	TOP ELEVATIONS Upper	Lower	REMARKS

		PIPE SCHEDULE		
SIZE	TYPE	CLASS/GAGE	LENGTH	REMARKS

APPENDIX 22

PERMISSIBLE FLOW VELOCITIES

Ditches and swales will be designed to restrict maximum permissible flow velocities for the ten-year frequency storm, and for various soil types, covers, and slopes as follows:

		PERMISSIBLE VELOCITY	
Cover	*Slope Range (percent)*	*Erosion Resistant Soils (fps)*	*Easily Eroded Soils (fps)*
Seeded Grasses	0 - 5	6	4
	5 - 10	5	3
	10	4	2
Sod	0 - 5	8	6
	5 - 10	7	5
	10	6	4
Permanent Sod Stabilization Mattings	Per Manufacturer Specs		
Bare Earth	0 - 5	5	3
	5	2	1
*Gabions:			
Twelve inches thick	-	10	10
Eighteen inches thick	-	15	15
Paved Channels	-	20	20
*Riprap:			
Minimum diameter=0.5 feet	-	6	4
Minimum diameter=1.0 feet	-	8	6
Minimum diameter=2.0 feet	-	12	10

(A) Velocities should be reduced by twenty-five (25) percent for a meandering channel with bends (radius one hundred (100) feet).

(B) Velocities exceeding five (5) fps can only be used where good cover and proper maintenance are assured.

(C) Erosion-resistant soils are defined by the soil erodability factor (k) in the universal soil loss equation with K 0.35. Easily eroded soils are defined by 0.35.

*May be used only when all other methods are shown to be infeasible.

APPENDIX 23

HYDRAULIC GRADIENT FOR STORM SEWERS

DESIGNED BY: _____ PROJECT NAME: _____ SHEET ___ OF ___

CHECKED BY: _____ SECTION or PHASE: _____ DATE: _____

Structure		**___ Year Runoff**				**Pipe**								**Hydraulic Gradient**		
From	To	ΣCA	t_c Time Conc. Min.	i_f rainfall Intes. In./Hr.	Q Cfs	Size In.	n Mann-ing's Coef.	S_o Slope %	S_f Slope %	V_f Vel. ft/sec.	L Length ft.	d_n Norm. Depth ft.	K_b	Description of Loss	Head Loss @ Str.	Elevation

APPENDIX 24

STORM SEWER DESIGN

DESIGNED BY: _____ PROJECT NAME: _____ SHEET ___ OF ___

CHECKED BY: _____ SECTION or PHASE: _____ DATE: _____

Structure		**Contributing Area**					**___ Year Runoff**			**Pipe**									**Remarks**
From	To	A Area Acres	Runoff Coef.	Δ CA	ΣA	ΣCA	t_c Time Conc Min.	I_f rnfall Intes. In./Hr	Q cfs	Size In.	Type	n Manning's Coef.	S_o Slope % Min.	S_o Slope % Act.	L Length Ft.	V_o Vel. ft./sec.	Time in Pipe Min.	Capac Full Cfs	Note: Provide V act. At Outfall Structures

APPENDIX 25

INLET SPACING

DESIGNED BY: _____ PROJECT NAME: _____ SHEET ___ OF ___

CHECKED BY: _____ SECTION or PHASE: _____ DATE: _____

Inlet No.	Area Acres	C	CA	By-Pass CA	Total CA	T_c Min.	I_2 i_f "/hr	Q_2 cfs	Inlet Type	Cross Slope	Chart No.	Street Grade	spread ft.	Pickup %	Bypass to CA	Inlet to No.	Remarks

APPENDIX

PROJECT: _____ DESIGNER: _____

DATE: _____

HYDROLOGIC AND CHANNEL INFORMATION

Q_1 = _____ TW_1 = _____

Q_2 = _____ TW_2 = _____

(Q_1 = DESIGN DISCHARGE, SAY Q_{25}
Q_2 = CHECK DISCHARGE, SAY Q_{50} OR Q_{100})

SKETCH

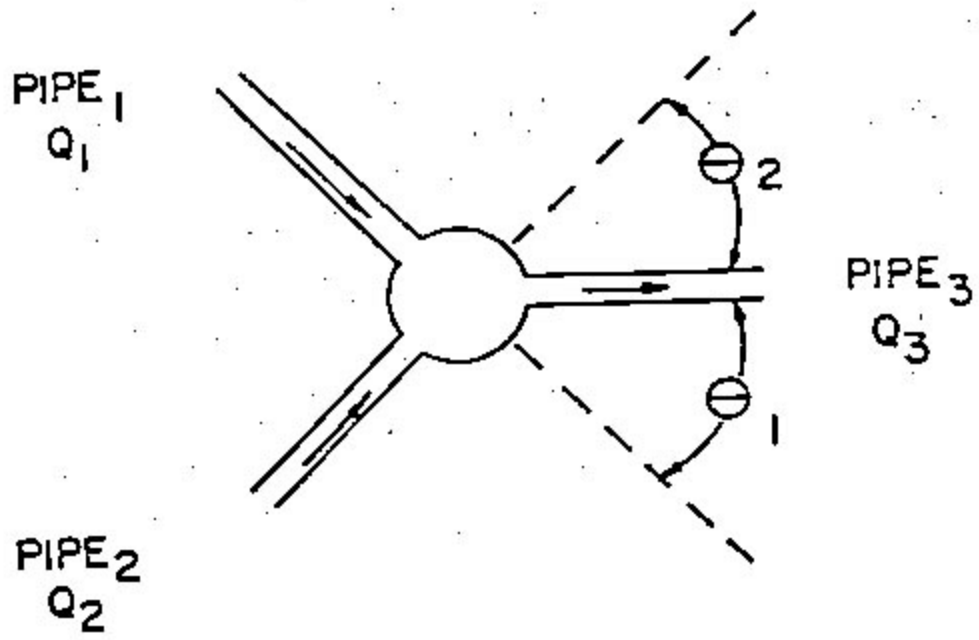
STATION: _____

MEAN STREAM VELOCITY = _____

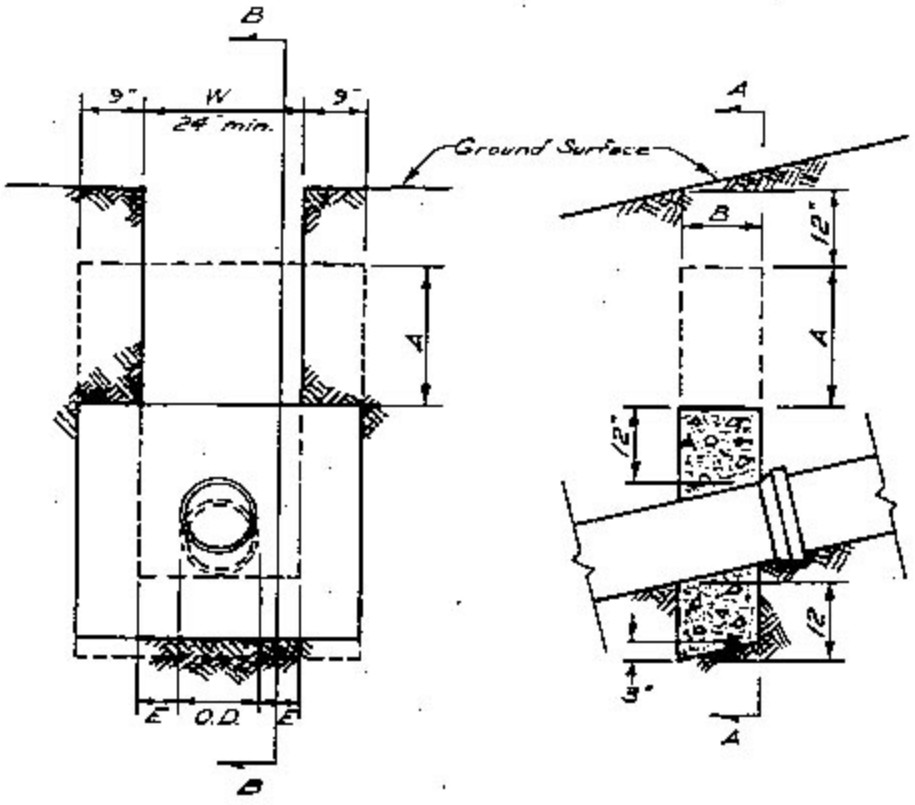
MAX. STREAM VELOCITY = _____

CULVERT DESCRIPTION (ENTRANCE TYPE)	Q	SIZE	HEADWATER COMPUTATION										CONTROLLING H.W.	OUTLET VELOCITY	COST	COMMENTS
			INLET CONT.		OUTLET CONTROL HW=H+h_o-LS_o											
			$\frac{HW}{D}$	HW	K_e	H	d_c	$\frac{d_c+D}{2}$	TW	h_o	LS_o	HW				

SUMMARY & RECOMMENDATIONS:


PIPE 1
Q1
2
PIPE 3
Q3
1
PIPE 2
Q2

APPENDIX 28



Section "A-A" Section "B-B"

A - Extension of anchor to 12" below ground surface, when necessary to prevent washout of backfill by surface water.
B - 12" for pipes 10" or less, 18" for pipes 10" to 18" nominal dia.
W = O.D. + 2E

1. Provide no anchors on grades less than 20% unless noted.
2. Provide anchors 36' ctr. to ctr. on grades between 20% & 34%.
3. Provide anchors 24' ctr. to ctr. on grades between 34% & 50%.
4. Provide anchors 16' ctr. to ctr. on grades between 50% & 70%.
5. All anchors to be Md. S.H.A. mix no. 1 concrete, placed downgrade of bell, as shown above.

APPENDIX

K.C.H.

Frederick County Division of Public Works	Revisions Date / Note	Concrete Anchors for Pipe installed on Grades 20% or More	Detail No.
			Date: 2-20-90